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Paz

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(54) **VACUUM PUG MILL**

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CPC ***B01F 7/0065*** (2013.01); *B01F 2215/0047* (2013.01)

(58) **Field of Classification Search**
CPC B01F 7/0065; B01F 13/06; B01F 2015/0084; B01F 2015/0009; B01F 2015/00097; B01F 2015/00103; B28C 1/22
USPC 366/75, 99, 139, 325.1, 331; 425/203
See application file for complete search history.

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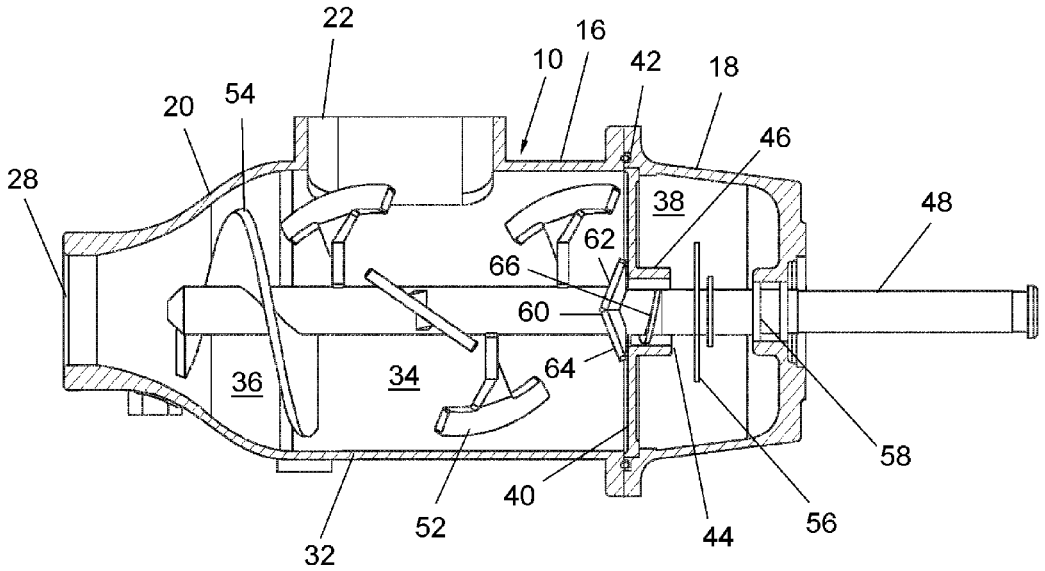
(57) **ABSTRACT**

A pug mill having a housing and a cantilevered shaft extending through the housing includes, in seriatim, a vacuum chamber, a wall, a mixing chamber and a reduction cone. A communication port about the shaft is positioned in the wall between the vacuum chamber and the mixing chamber. Vacuum can be maintained within the mixing chamber by air passing through the port. An auger associated with the shaft forces clay toward the reduction cone. This creates a seal for maintaining vacuum within the mixing chamber and extrudes cylindrical blocks of conditioned clay without significant air bubbles. A deflection plate rotating with the shaft and a spiral element about the shaft keep the communication port clear. The shaft is eccentrically mounted. The dividing wall is removable.

9 Claims, 4 Drawing Sheets



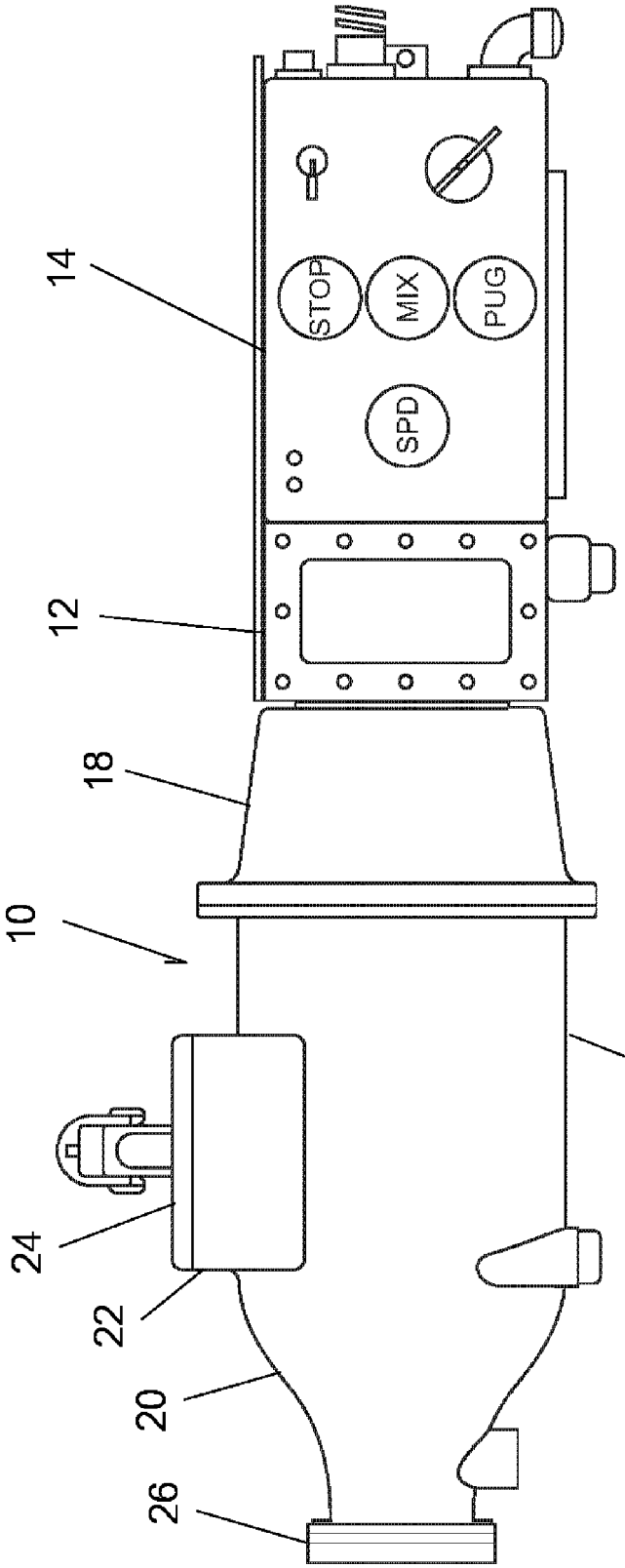


FIG. 1

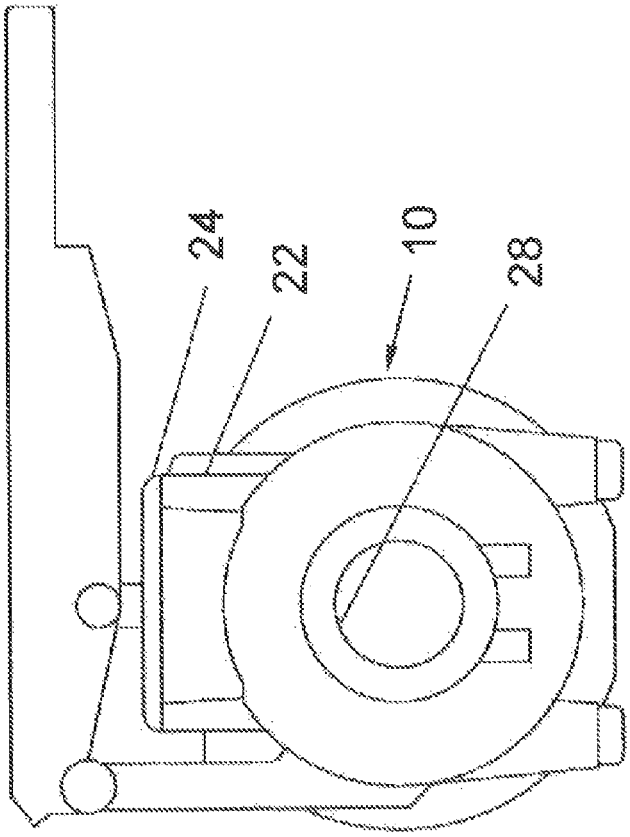


FIG. 2

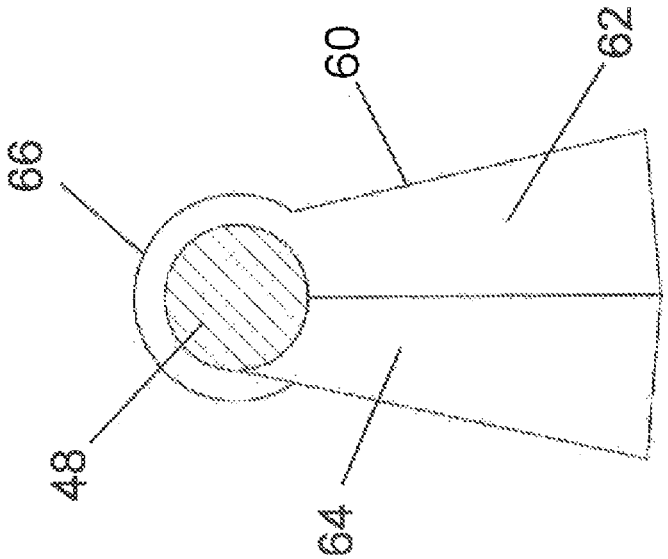


FIG. 5

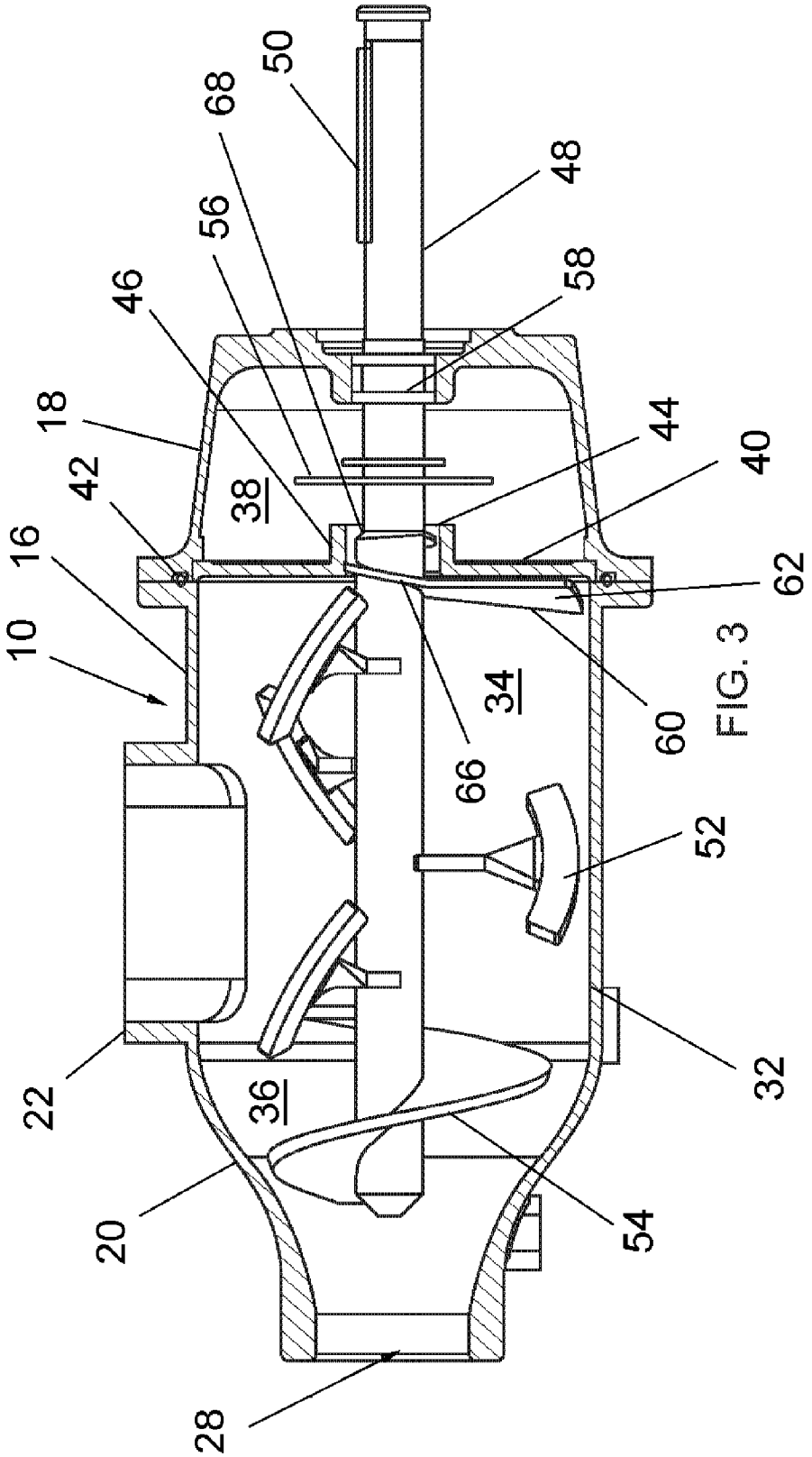


FIG. 3

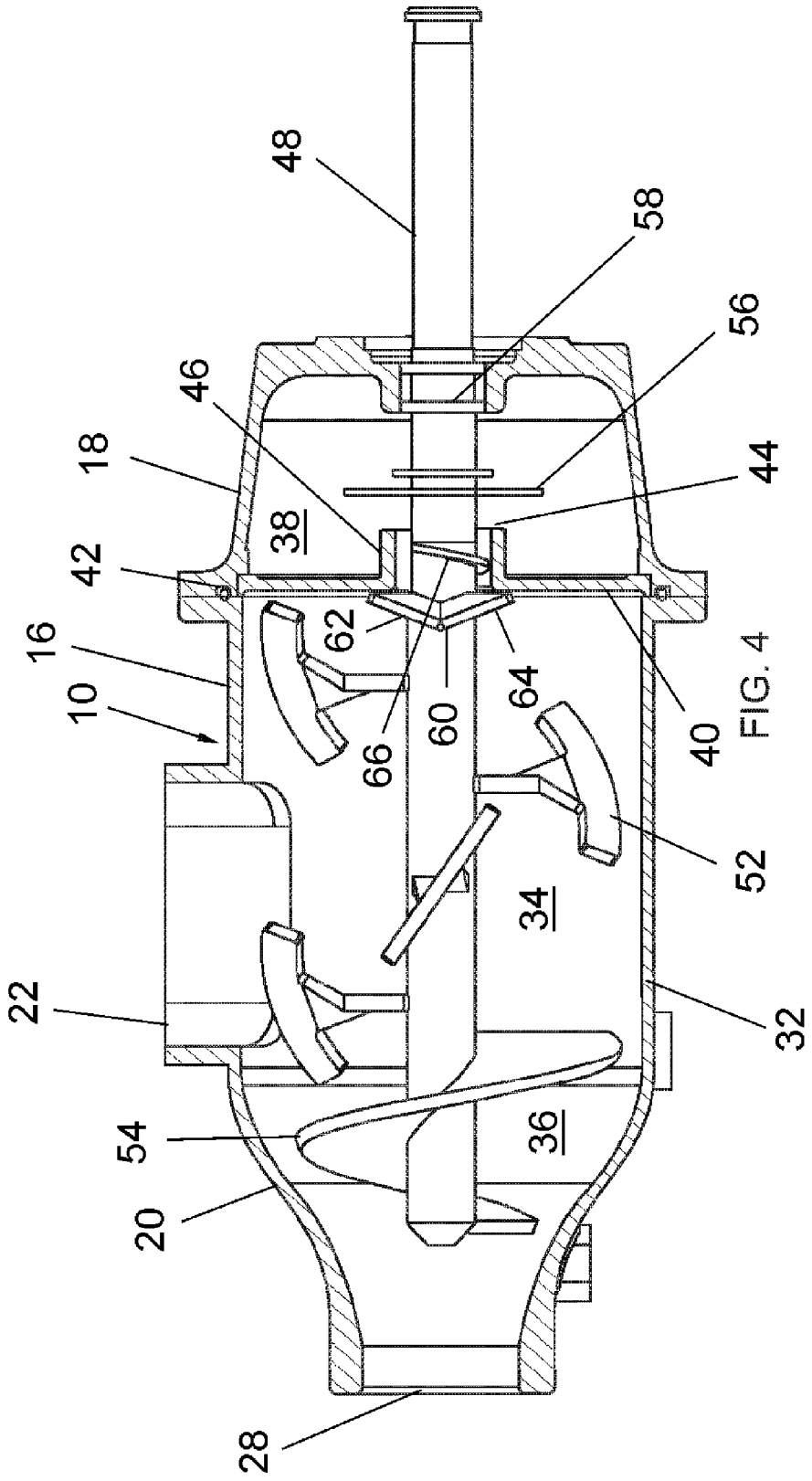


FIG. 4

VACUUM PUG MILL

BACKGROUND OF THE INVENTION

The field of the present invention is pug mills for mixing and conditioning clay for ceramics.

Pug mills are designed for producing clay conditioned for the manufacture of ceramics. The mills typically are used to mix clay powder and water or rehydrate, remix and/or recondition existing clay. Powders and water may also be mixed with existing clay to form a homogeneous product. The clay, once mixed, is most conveniently extruded through a reduction cone to form cylindrical or rectangular blocks also known as pugs.

Pug mills upon which the present design is based are disclosed in U.S. Pat. No. 4,322,169 entitled CLAY MIXING APPARATUS and U.S. Pat. No. 5,716,130 entitled VACUUM PUG MILL, the disclosures of which are incorporated herein by reference in their entirety. These pug mills include a mixing chamber expending to an extruder in communication therewith. A shaft is rotatably mounted relative to the mixing chamber and the extruder. Mixing blades associated with the mixing chamber are fixed to the shaft as is an auger associated with the extruder. The shaft is rotatably mounted by bearings such that an extension of the shaft through the mixing chamber and the extruder is cantilevered from the bearings. The bearings are positioned in a housing including a drive motor and drive train for forcibly rotating the shaft. The shaft is rotatable in either direction about its axis. When rotated in a first direction, mixing takes place. When rotated in a second direction, the clay is advanced by the mixing blades and by the auger for extrusion through the reduction cone.

In addition to the conditioning of clay to achieve an appropriate moisture content and homogeneity, it is advantageous to remove as much air as possible. Air entrapped in the clay when fired can expand to ruin the article manufactured. Also, entrapped air can adversely affect throwing operations as it makes the clay "short" and hard to work with. The pug mill disclosed in U.S. Pat. No. 5,716,130 provides a vacuum chamber in communication with the mixing chamber for drawing a vacuum on the clay to remove air from being mixed into the clay. A cover on the end of the reduction cone or a solid body of clay being extruded therefrom provides a sealed mixing chamber to permit the drawing of the vacuum.

U.S. Pat. No. 5,716,130 provides a mechanism for maintaining a clear communication port between the mixing chamber and the vacuum chamber of that mill. It remains that material being pugged can still overwhelm the communication port and interrupt the application of vacuum in the mixing chamber.

SUMMARY OF THE INVENTION

The present invention is directed to a pug mill which provides for vacuum associated with the mixing process with enhanced communication of vacuum from the mixing chamber to the vacuum chamber.

In a first aspect of the present invention, the pug mill includes a mixing chamber and a vacuum chamber with a wall therebetween. The wall includes a communication port. A pug mill shaft extends through the communication port. A deflection plate is fixed on the rotatably mounted shaft in the mixing chamber immediately adjacent the wall and extending radially outwardly from the shaft beyond the communication port. The deflection plate has two deflection surfaces which each extend at a shallow incline away from adjacent the wall to meet at a common apex.

In a second aspect of the present invention, the pug mill of the first aspect further includes a spiral element fixed about the shaft and extending from the deflection plate through the communication port. The spiral element includes clearance through the communication port to allow air to pass from the mixing chamber to the vacuum chamber.

In a third aspect of the present invention, the pug mill includes a mixing chamber and a vacuum chamber with a wall therebetween. The wall includes a communication port. A pug mill shaft extends through the communication port. The shaft of the pug mill is eccentrically mounted at least as to the mixing chamber to allow enhanced access of the vacuum to the body of the material being mixed.

In a fourth aspect of the present invention, the pug mill includes a mixing chamber and a vacuum chamber with a wall therebetween. The wall includes a communication port between the mixing chamber and the vacuum chamber. The chambers each include a housing. The housings mate together with the wall being removable for critical accommodation of various mixing materials.

In a fifth aspect of the present invention, any of the foregoing aspects may be combined to greater advantage.

Therefore, it is a principal object of the present invention to provide an improved vacuum pug mill. Other and further objects and advantages will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation of a pug mill;

FIG. **2** is an end view of the pug mill of FIG. **1**;

FIG. **3** is a cross-sectional elevation at the center plane of the pug mill of FIG. **1**;

FIG. **4** is a cross-sectional elevation at the center plane of the pug mill of FIG. **1** with the shaft rotated 90° from the position shown in FIG. **3**;

FIG. **5** is a front view of the deflection plate on the shaft of the pug mill.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning in detail to the drawings, a pug mill is illustrated in FIGS. **1** and **2**. The assembly includes a sealable chamber housing assembly **10**, a gear casing **12** and a power box **14**. The housing assembly **10** encloses a sealable chamber defined by a mixing chamber housing **16** and a vacuum chamber housing **18**. The mixing chamber housing **16** includes a reduction cone **20** at the end of the housing **16**, an access port **22** and a hatch cover **24** for access to the interior of the sealable chamber. A cover **26** covers an extrusion port **28** at the end of the reduction cone **20** for selectively sealing the sealable chamber. The gear casing **12** and power box **14** provide controls, a drive motor and gearing for driving a shaft extending through the vacuum chamber housing **18** and mixing chamber housing **16**. A source of vacuum (not illustrated) is provided in communication with the vacuum chamber housing **18** through the power box **14** as well. The vacuum chamber housing **18** also includes an access port and cover to allow cleaning out of any clay material which may accumulate in the chamber.

Turning to FIGS. **3** and **4**, a mixing chamber **32** is revealed within the mixing chamber housing **16**. This chamber **32** includes a mixing zone **34** and an auger zone **36**. The mixing zone **34** is generally cylindrical while the auger zone **36** includes the reduction cone **20** leading to the extrusion

port **28**. The vacuum chamber housing **18** is revealed in FIGS. **3** and **4** to include a vacuum chamber **38**.

A wall **40** is located between the mating housings **16** and **18**. In the embodiment illustrated, the wall **40** is positioned in a channel cut into the mating face of the vacuum chamber housing **18** and held in place by the abutting mixing chamber housing **16**. A seal **42** is located outwardly of the wall **40** between the mating flanges of the mixing chamber housing **16** and the vacuum chamber housing **18**. The wall **40** may also be retained in this position through attachment to one or the other of the housings **16**, **18**. The wall **40** divides the sealable chamber between the mixing chamber **32** and the vacuum chamber **38** and includes a communication port **44** therethrough to provide vacuum throughout the sealable chamber. A circular flange **46** extends the communication port into the interior of the vacuum chamber **38**.

A shaft **48** is rotatably mounted to the closed end of the vacuum chamber housing **18** as well as in the gear casing **12** to extend through the vacuum chamber **38** and the mixing chamber **32** to the reduction cone **20**. The shaft **48** includes a key **50** to couple with a hollow shaft gear within the gear casing **12**. The shaft **48** is powered by a motor (not illustrated) through the gear casing **12** and can be controlled to be driven in either direction. Mixing paddles **52** are attached to the shaft **48** so as to be located in the mixing chamber **32**. A wide range of such paddle configurations and placements may be employed. The flight of an auger **54** is located at the end of the cantilevered shaft **48** to reside within the auger zone **36**. A deflection disc **56** extends radially about the shaft **48** within the vacuum chamber **38** to define a barrier to prevent clay material from moving along the shaft to the seal bearings **58**. The deflector disc **56** is shown displaced from both the wall **40** and the seal bearings **58**.

A deflection plate **60** is also fixed to the shaft **48**. The location of the deflection plate **60** on the shaft **48** places the deflection plate immediately adjacent the wall **40** on the mixing chamber side. It is preferable that the deflection plate **60** be as close as practical to the wall **40** and yet not touch the wall as the shaft **48** rotates. The deflection plate **60** extends radially outwardly from the shaft **48** beyond the extent of the communication port **44**. The deflection plate **60** includes two deflection surfaces **62**, **64** facing the mixing chamber **32**. These surfaces **62**, **64** each extend at a shallow incline away from the adjacent wall **40** to meet at a central radial apex, the two surfaces being symmetrical about the apex as seen in FIGS. **4** and **5**. A spiral element **66** affixed to the shaft **48** extends from the deflection plate **60** through the communication port **44**. Sufficient clearance for air to pass through the communication port **44** about the shaft **48** and spiral element **66** is also provided.

The pug mill operates by controlling the rotational direction of the shaft **48**. With the shaft rotating in one direction, the mixing paddles **52** and the auger **54** urge the clay material within the mixing chamber **32** toward the wall **40** so as to remain in the mixing chamber **32**. When the rotation of the shaft **48** is reversed, the mixing paddles **52** and the auger **54** advance the clay material away from the wall **40** through the reduction cone **20** and the extrusion port **28**.

With the rotation of the deflection plate **60**, the leading deflection surface **62** resists the movement of the advancing clay material toward the communication port **14** with the mill in the mixing mode. The other deflection surface **64** also urges the clay material away from the communication port **44** with the shaft rotating in the other direction in the extrusion mode. The spiral element **66** spirals in the opposite direction from the flight of the auger **54** and the inclination of the mixing paddles **52**. The spiral element **66** thus advances clay material entering the communication port **44** back toward the mixing chamber **32** when the mixing paddles **52** and the flight of the auger **54** are moving the clay material toward the communication port **14**. With the shaft **48** rotating in the opposite direction, the mixed material moves toward the extrusion port **28** away from the wall **40**, providing relief to the spiral element **66** which is then rotating in a way which would urge clay material to move into the vacuum chamber **38**. During operation with the vacuum source actuated, it has been found that a cycling of the shaft **48** through rotation in both directions can assist in keeping the mixed material away from the communication port **44**.

In the preferred embodiment, the shaft **48** is also eccentric to the rotational axis at least in the area of the mixing chamber **32**. The shaft **48** is shown to be displaced laterally from that axis at position **68** by a small amount. Clearance is provided for the spiral element **66**, the mixing paddles **52** and the auger **54** within the sealable chamber to accommodate the eccentricity. By eccentric rotation of the shaft **48**, a pathway may be generated along the shaft **48** for the extraction of air from the body of clay material being mixed.

Thus, a pug mill with improved air extraction is disclosed. While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art that many more modifications are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims.

What is claimed is:

1. A pug mill comprising

a sealable chamber;

a wall dividing the sealable chamber into a mixing chamber and a vacuum chamber, the wall including a communication port therethrough in communication with the mixing chamber and the vacuum chamber;

a shaft rotatably mounted about a rotational axis relative to and extending into the mixing chamber through the communication port;

a deflection plate fixed on the rotatably mounted shaft in the mixing chamber immediately adjacent the wall and extending radially outwardly from the shaft beyond the communication port, the deflection plate having two deflection surfaces, each of the two surfaces extending at an incline away from adjacent the wall and meeting at a common apex extending radially from the shaft, the two surfaces being symmetrical about the apex.

2. The pug mill of claim **1**, further comprising a spiral element fixed about the shaft extending in the communication port away from the deflection plate with clearance for air to pass through the communication port.

3. The pug mill of claim **2**, the shaft including an auger with a flight for advancing material away from the wall with rotation in a first direction, the spiral element fixed about the shaft advancing material away from the auger with rotation in the first direction.

4. The pug mill of claim **3**, the sealable chamber including a mixing chamber housing and a vacuum chamber housing which mate together at the wall, the wall being separable from both the mixing chamber housing and the vacuum chamber housing.

5. The pug mill of claim **1**, the shaft being eccentric to the rotational axis in the mixing chamber.

6. The pug mill of claim **1**, the sealable chamber including a mixing chamber housing and a vacuum chamber housing

which mate together at the wall, the wall being separable from both the mixing chamber housing and the vacuum chamber housing.

7. The pug mill of claim **6**, the shaft being eccentric to the rotational axis in the mixing chamber.

8. The pug mill of claim **1**,

the mixing chamber including a reduction cone displaced from the wall, the shaft including mixing paddles in the mixing chamber and an auger extending into the reduction cone.

9. The pug mill of claim **8**, the mixing chamber further including an extrusion port at the reduction cone having a cover to selectively seal the extrusion port.

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